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Institutional grid data in weather-index insurance: A value added for agricultural producers?

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Context/Theoretical background/Research question

Motivated by asymmetric information problems of indemnity based crop insurances, the idea of index-based products is frequently discussed for agricultural applications. Here a payout occurs, if a predefined state of a trigger value (e.g. a weather variable) is realized (e.g. Turvey, 2001). Therefore weather index insurance (WII) is of growing interest in agricultural economics research and an increasing number of companies offer these solutions also in Europe (e.g. Zurich based CelsiusPro AG). However, a major issue in this context is basis risk, which consists of design basis risk, geographical basis risk and temporal basis risk (see Leblois et al. 2014a). Here, we address the latter two types of basis risk and build upon earlier research to address the first (following Conradt et al., 2015a).

To overcome the issue of geographical basis risk, former research suggested the use of local weather station data (Woodard & Garcia, 2008), interpolation of weather information through kriging (Norton et al., 2015, Paulson et al., 2010) or the development of a gridded weather layer for the region of interest (The World Bank, 2013). Further a portfolio of insurance contracts is proposed to decrease geographical basis risk as well (Berg & Schmitz, 2008, Norton et al., 2012, Ritter et al., 2014, Woodard & Garcia, 2008). However, all these methods have in common that traceability decreases and transaction costs increase with increasing complexity of the model (Ritter et al., 2014). This trade-off between data precision and traceable index building limits the development of private index insurance markets (Leblois et al., 2014b, Patt et al., 2009). Therefore precise weather information for on-farm location provided in a traceable manner is obligatory. Concerning temporal basis risk, the often used strategy to employ time windows in which an index is measured that are fixed over years, such as precreation in a specific month (see e.g. Berg & Schmitz, 2008, Pelka & Musshoff, 2013) cause a high degree of basis risk. To overcome this shortcoming, a more explicit consideration of crop growth stages has been suggested, e.g. by using growing degree days (e.g. Conradt, 2015a).

Despite various efforts made to improve WII, earlier research has not considered the increasing availability of new objective data sources on weather and crop phenological phases provided by independent state institutions. Based on this background, we aim to improve the available options for index based insurance in order to reduce basis risk. More specifically, we aim to test two hypotheses: First, that the use of institutionally provided (freely and live available) weather grid data improves risk management opportunities of rainfall index insurance products. Second, that regional phenological observations as provided by weather data provider (in our case Der Deutsche Wetterdienst, DWD) outperforms usually employed fixed periods (time windows). To this end, we use an example of panel data for German wheat producers, precipitation grid data and phenological information provided by DWD.

Methodology

We evaluate potential benefits of utilizing gridded precipitation data compared to weather station data in precipitation index insurance framework. The weather data is provided by DWD, a public and independent German weather data provider. Rainfall data is given within a 1 x 1 km grid, interpolated using the 'RegNie' procedure as described in Rauthe et al. (2013) and Fosser (2013). Interpolation of weather station data into the grid layer is made by coping for inverse distance, longitude, latitude, altitude as well as direction and amount of exposition. The dataset is freely and promptly available for around 600,000 locations all over Germany (available at ftp://ftp-cdc.dwd.de/). For about 1200 locations DWD provides phenological observations of growing phases for a variety of plants (DWD 1991). As also this data is freely available online (ftp://ftp-cdc.dwd.de/) it is highly recommended to take this information into account when designing index insurance. Risk reducing properties are evaluated for a panel of 29 winter wheat producing farms located in central Germany. The yield data comprises 15 years from 1996 to 2010 detrended using linear trends. Mean yield was 8.69 t/ha, standard deviation on average 1.45 t/ha (see Pelka & Musshoff, 2013). A lack of rainfall is the main risk in our case study, motivating the use of a precipitation sum index based on accumulated daily rainfall to find index values (see Leblois & Quirion (2013) for further examples). To determine optimal start and end dates we compare the common practice of monthly aggregation (e.g. Pelka & Musshoff, 2013) to coping for water sensitive crop growing phases by taking into account phenological observations within the farms' natural region (defined by Ssymank, 1994). We estimate the yield ~ index dependencies applying Quantile Regression (QR) for each of the 29 farms to concentrate on downside risks (Conradt et al., 2015b). Ticksize (Slope Coefficient) and Strike Level (inverse value of mean yields) are obtained from the regression results. Premiums are assumed to be fair and determined via Burn Rate approach. In order to assess whether WII is beneficial for farmers, we use the expected utility (EU) framework. Coherent with our focus on downside risks, we use a power utility function. We use nonparametric Wilcoxon rank test to test whether i) grid data outperforms station data and ii) monthly accumulation outperforms accumulation based on phenological observations (based on the superior option i)). To account for differences in risk aversion, we use different levels of the Arrow Pratt coefficient of relative risk aversion, i.e. 0, 0.5, 1, 2, 3 and 4.

Results

In contrast to our expectation, we find that using gridded precipitation data as provided by DWD in designing weather index insurance significantly reduced EU of case study farmers. However, this result depends on risk preferences. While for risk neutral and low risk averse decision makers, no difference exist, the effect becomes more pronounced for higher levels of risk aversion. Concerning the performance of using phenological observations, we find that products conditioned based on phenological observations significantly increased expected utility of farmers compared to the case of insuring via monthly aggregated rainfall. The highly significant results are independent of the assumed levels of relative risk aversion.

Conclusion

According to our results, we reject the hypotheses of precipitation grid data providing value added for index insurance practitioners in the study region. This could be based on the fact that the grid model underestimates the occurrence of dry days and therefore downside risks (Fosser, 2013). Further, weather station density was rather high in our sample, as the mean distance between farm and station location was 8.5 km with a minimum of 0.45 km and a maximum of 18 km. However, even if grid data is not yet favorable, potential disadvantages of current research approaches with respect to traceability, should stimulate the development of institutionally provided grid data especially designed for insurance practice to supply local insurance industry without providing premium subsidies. We cannot reject our hypothesis concerning phenological observations as we find those to significantly contribute to a reduction of basis risk. Coping for growing phases is in line with recent findings of Conradt (2015a), however phenological observations have not yet been considered in weather index insurance research. Based on our results and the fact that these data sources are becoming also increasingly available in other European countries (e.g. Meteoswiss, 2015a, 2015b) as well as the increasing availability of satellite data (see Leeuw et al., 2014), indicates a high potential for improvements in WII solutions also beyond the German case study investigated here. Further research should take additional datasets into account that combine interpolation and radar observations into a grid layer, as this methodology increases accuracy in extreme event estimation (i.e. Radolan for Germany (ftp://ftp-cdc.dwd.de/)(n.a. for our study), Wüest et al. (2010) for Switzerland).

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